CITY OF THORNTON

Appendix B

ANALYSIS METHODOLOGY

Memorandum

Date: November 21, 2024

To: City of Thornton

From: Fehr & Peers

Subject: Thornton Vision Zero Action Plan Analysis Methodology

DN23-0802

This memorandum outlines the methodologies used to develop Thornton's Vision Zero Action Plan. The following sections describe the development of the High Injury Network + High Risk Network, Level of Service of Safety Analysis, and priority location identification.

High Injury Network + High Risk Network Identification

High Injury Network

The High Injury Network (HIN) represents roadway segments with a disproportionately high number of crashes, and particularly severe crashes, per mile. HIN development used a "sliding window" approach[1] to associate crashes with street segments. In this approach, crashes within a specified distance from a roadway are joined to a segment of specified length (the "window"). The window is then shifted slightly, and the process repeated, until the entire network has been assessed with a series of overlapping windows (Figure 1). Compared to an approach based on

[1] Texas A&M Transportation Institute, 2017. "Innovative Tools and Techniques in Identifying Highway Safety Improvement Projects: Technical Report." Available at https://static.tti.tamu.edu/tti.tamu.edu/documents/0-6912-1.pdf.

analyzing discrete blocks, the sliding window approach accounts for collision density up- and downstream of each analysis window, making it more likely to identify systemic patterns. This approach also smooths errors in crash location reporting.

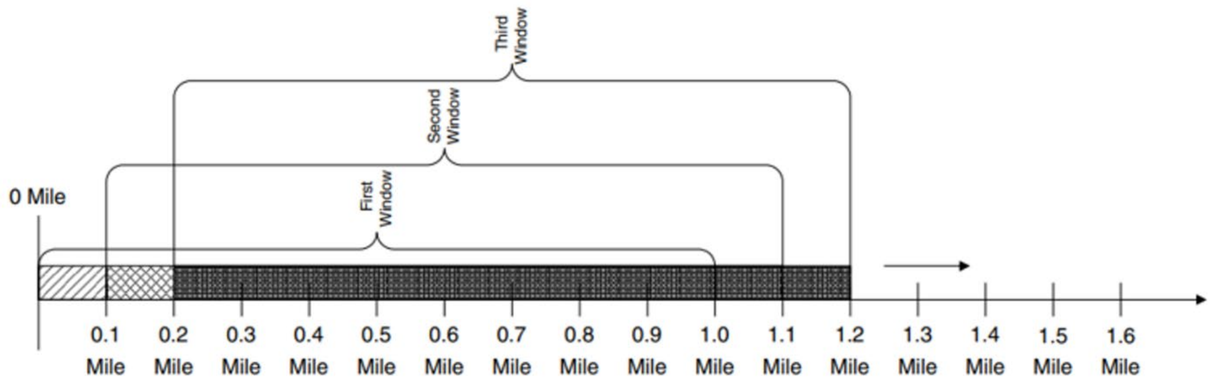

Figure 1: The sliding window approach attributes crashes to overlapping roadway segments, creating a smooth and accurate High Injury Network. (Source: Texas A&M Transportation Institute)

Fehr & Peers has developed a proprietary ArcGIS Pro geoprocessing tool based on Python scripts to conduct the sliding window analysis and smooth the results into a HIN. For the analysis for the City of Thornton, the window length was set to 1,320 feet, the window shift to 528 feet, and the crash search radius to 50 feet. All crash types were given equal weight.

After running the sliding window tool, a second script isolated segments that scored in the 98th percentile for crash frequency and smoothed them such that segments up to 2,640 feet apart were joined together. The resulting smoothed line network forms the HIN.

High Risk Network

The High Risk Network (HRN) in Thornton was developed by identifying a set of contextual factors most associated with fatal and injury crashes and then mapping street segments in the city with a high concentration of overlapping risk factors. The first step in this process was to identify the risk factors.

Contextual Risk Factors

Contextual factors are aspects of the physical environment present at the time of the crash that may have influenced the outcome of the crash or whether it occurred at all, such as crosswalks or streetlights. Each crash resulting in injury or death that occurred in Thornton between 2018 and

2022 was assessed for the presence or absence of various contextual factors. Sixteen contextual were analyzed, each with two or more sub-factors:

1. Roadway functional class
2. Pavement condition
3. Intersection type (signalized, etc.)
4. Pedestrian intersection type (pedestrian signal, crosswalk, etc.)
5. Pedestrian & bicycle facilities (sidewalk, bike lane, etc.)
6. Land use category
7. Destination type (city facility, transit stop, school, etc.)
8. Public comment
9. Traffic volume
10. Left turn signal phase
11. Household vehicles available
12. Household income
13. Posted speed
14. 85% operating speed
15. Frequency of quick acceleration
16. Frequency of hard braking

Table 1 shows the systemic safety matrix of all contextual factors analyzed compared to different crash attributes.

Table 1. Systemic Safety Matrix

Contextual Factor							Functional Class					Pavement Condition		Location Type							Pedestrian and Bike			Land Use						
														Intersection				Pedestrian												
Contextual Factor - detail							Local	Collector	Arterial	Highway or Ramp	Missing data	Fair	Good or Excellent	Signalized	Unsignalized	Roundabout	Midblock	Pedestrian refuge island	Pedestrian Signals	Crosswalk	Sidewalk	Trails	BikeFacilities	Single Family/Duplex	Multifamily	Commercial/Institutional	Agricultural/Rural	Industrial	Other	No Data Available
												<=59	>=60																	
Total length (miles)							633					633		633							536	273	149	633						
Length per attribute (miles)							435	83	99	16	0	2	408	67	365	11	191	2	12	240				467	97	159	26	19	319	21
Total length (feet)							3,342,674					3342674		3,342,674							2,830,749	1,440,339	785,754	3,342,674						
Length per attribute (feet)							2,299,248	436,673	522,285	84,468	0	11,480	2,154,078	353,666	1,926,419	56,375	1,007,927	9,120	64,332	1,269,182				2,465,107	511,514	836,952	139,157	98,634	1,682,156	111,949
Crash Rate (3/mile)																														
	Cell Value	Alias1	Alias2	Alias3																										
Human Contributing Factors	Driver Inexperience				180	380	0.04	0.31	1.35	0.06	0.00	1.38	0.40	1.61	0.20	0.19	0.35	0.00	0.25	0.52	0.25	0.34	0.55	0.15	0.06	0.45	0.15	0.05	0.04	0.57
	Driver Preoccupied				143		0.01	0.13	1.25	0.13	0.00	0.00	0.33	1.28	0.16	0.00	0.27	0.58	0.16	0.41	0.18	0.27	0.36	0.11	0.06	0.33	0.15	0.05	0.04	0.80
	Aggressive Driving				57		0.01	0.04	0.52	0.00	0.00	0.46	0.13	0.57	0.05	0.00	0.08	0.00	0.00	0.17	0.10	0.13	0.20	0.04	0.00	0.19	0.00	0.00	0.02	0.14
Crash Type	Unknown				0	1790	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Bicycle or Pedal Cycle				58		0.01	0.18	0.37	0.00	0.00	0.00	0.13	0.48	0.07	0.00	0.06	0.00	0.08	0.18	0.09	0.12	0.21	0.06	0.01	0.15	0.00	0.00	0.01	0.05
	Domestic Animal				0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Other Non-Collision				9		0.00	0.05	0.05	0.00	0.00	0.00	0.02	0.04	0.02	0.00	0.03	0.00	0.00	0.02	0.01	0.01	0.03	0.01	0.00	0.01	0.00	0.00	0.01	0.00
	Pedestrian				85		0.03	0.12	0.65	0.00	0.00	0.46	0.19	0.66	0.11	0.00	0.17	0.00	0.25	0.23	0.15	0.19	0.31	0.08	0.03	0.22	0.04	0.00	0.01	0.19
	Embankment or Ditch				0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Head On				38		0.01	0.06	0.27	0.00	0.00	0.46	0.08	0.24	0.06	0.00	0.14	0.00	0.00	0.06	0.05	0.09	0.10	0.05	0.01	0.06	0.11	0.00	0.00	0.05
	Overturning				47		0.01	0.19	0.28	0.00	0.00	0.92	0.10	0.30	0.07	0.09	0.17	0.00	0.08	0.12	0.07	0.07	0.11	0.04	0.04	0.11	0.08	0.00	0.01	0.05
	Sideswipe Opposite Direction				16		0.00	0.06	0.10	0.00	0.00	0.00	0.03	0.09	0.03	0.00	0.06	0.00	0.00	0.03	0.02	0.03	0.06	0.02	0.00	0.03	0.04	0.00	0.00	0.00
	Wild Animal				1		0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00
	Overtaking Turn				23		0.01	0.01	0.18	0.00	0.00	0.00	0.05	0.19	0.03	0.00	0.05	0.00	0.00	0.06	0.03	0.04	0.07	0.02	0.01	0.05	0.00	0.00	0.00	0.19
	Parked Motor Vehicle				28		0.03	0.16	0.02	0.00	-708669603840.00	0.00	0.06	0.01	0.07	0.00	0.14	0.00	0.00	0.03	0.05	0.03	0.04	0.06	0.00	0.01	0.00	0.00	0.00	0.00
	Approach Turn				347		0.02	0.39	3.03	0.25	-354334801920.00	2.76	0.79	3.94	0.23	0.00	0.29	0.00	0.08	1.17	0.48	0.72	1.22	0.22	0.04	1.07	0.27	0.00	0.11	1.32
	Fixed Object				149		0.03	0.52	0.90	0.19	-708669603840.00	1.84	0.31	0.72	0.28	0.66	0.61	0.58	0.33	0.29	0.19	0.27	0.34	0.14	0.11	0.20	0.27	0.05	0.04	0.90
	Other Object				4		0.00	0.01	0.03	0.00	0.00	0.00	0.01	0.03	0.01	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.05
	Sideswipe Same Direction				62		0.00	0.01	0.60	0.00	0.00	0.00	0.14	0.46	0.08	0.00	0.20	0.00	0.08	0.17	0.10	0.15	0.22	0.04	0.00	0.20	0.00	0.00	0.02	0.14
	Broadside				361		0.04	0.54	2.98	0.06	-1063004405760.00	0.46	0.83	3.19	0.40	0.00	0.34	0.00	0.00	1.02	0.51	0.75	1.07	0.26	0.09	1.00	0.19	0.05	0.10	1.65
	Rear End				562		0.04	0.42	5.04	0.44	-1771674009600.00	2.30	1.26	5.18	0.59	0.00	1.14	1.74	0.49	1.73	0.75	1.02	1.53	0.36	0.24	1.51	0.49	0.16	0.20	2.41
Movement (Vehicle 1)	Avoiding Object/Vehicle in Roadway				9	1783	0.00	0.01	0.08	0.00	0.00	0.00	0.02	0.06	0.01	0.00	0.03	0.00	0.00	0.02	0.01	0.03	0.03	0.01	0.00	0.01	0.04	0.00	0.00	0.00
	Backing				4		0.00	0.01	0.02	0.00	0.00	0.00	0.01	0.04	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
	Changing Lanes				44		0.00	0.01	0.41	0.00	0.00	0.00	0.09	0.34	0.06	0.00	0.17	0.00	0.08	0.12	0.07	0.11	0.19	0.03	0.01	0.14	0.00	0.00	0.01	0.09
	Drove Wrong Way				99		0.03	0.31	0.61	0.06	0.00	1.38	0.22	0.58	0.16	0.09	0.35	0.00	0.00	0.21	0.15	0.18	0.24	0.10	0.04	0.19	0.19	0.00	0.02	0.33
	Entering/Leaving Parked Position				0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Going Straight				951		0.11	1.45	7.70	0.69	-3189013217280.00	4.14	2.14	8.38	1.07	0.66	1.79	1.16	0.82	2.78	1.29	1.80	2.63	0.70	0.36	2.29	0.91	0.21	0.31	4.67
	Other				8		0.00	0.01	0.07	0.00	0.00	0.46	0.01	0.04	0.01	0.00	0.04	0.00	0.00	0.01	0.01	0.02	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00
	Making Left Turn				438		0.04	0.63	3.68	0.06	-708669603840.00	2.30	1.01	4.03	0.46	0.00	0.48	0.58	0.33	1.30	0.64	0.91	1.50	0.35	0.13	1.28	0.27	0.05	0.09	1.08
	Making Right Turn				95		0.01	0.15	0.79	0.00	0.00	0.92	0.20	0.91	0.09	0.00	0.13	0.00	0.00	0.31	0.14	0.21	0.32	0.06	0.01	0.33	0.00	0.00	0.01	0.33
	Making U-Turn				16		0.01	0.04	0.09	0.00	0.00	0.00	0.03	0.04	0.04	0.00	0.07	0.00	0.00	0.02	0.02	0.03	0.03	0.01	0.01	0.03	0.00	0.00	0.00	0.14
	Parked				1		0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
	Passing				7		0.00	0.01	0.05	0.00	0.00	0.00	0.01	0.03	0.01	0.00	0.03	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.09
	Slowing				72		0.01	0.04	0.63	0.13	-708669603840.00	0.00	0.15	0.75	0.06	0.00	0.17	0.00	0.08	0.21	0.09	0.12	0.19	0.05	0.01	0.18	0.11	0.00	0.04	0.19
	Stopped in Traffic				5		0.00	0.01	0.04	0.00	0.00	0.00	0.01	0.04	0.01	0.00	0.01	0.00	0.00	0.02	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00
	Weaving				12		0.00	0.01	0.11	0.00	0.00	0.00	0.03	0.06	0.02	0.00	0.04	0.00	0.00	0.02	0.02	0.03	0.05	0.02	0.00	0.01	0.00	0.00	0.00	0.00
	Unknown				22		0.00	0.02	0.18	0.00	0.00	0.00	0.04	0.19	0.02	0.00	0.06	0.58	0.08	0.07	0.04	0.04	0.09	0.02	0.00	0.08	0.00	0.00	0.00	0.05
Road Condition	Dry	Dry w/Visible	Dry w/Visi	Dry w/Visi	1597	1784	0.20	2.48	12.94	0.88	-4252017623040.00	8.74	3.56	13.94	1.82	0.75	2.98	2.32	1.40	4.62	2.25	3.10	4.79	1.22	0.53	4.14	1.25	0.21	0.46	6.37
	Wet	Wet w/Visible Road Treatment			107		0.01	0.12	0.94	0.06	0.00	0.00	0.25	0.96	0.12	0.00	0.19	0.00	0.00	0.30	0.15	0.22	0.31	0.07	0.05	0.30	0.15	0.00	0.03	0.33
	Snowy	Snowy w/Visible Snowy Treatment			40		0.01	0.05	0.32	0.00	0.00	0.00	0.09	0.31	0.05	0.00	0.10	0.00	0.00	0.08	0.06	0.08	0.07	0.04	0.00	0.08	0.04	0.05	0.01	0.14
	Icy				26		0.01	0.07	0.16	0.00	0.00	0.46	0.06	0.19	0.04	0.00	0.07	0.00	0.00	0.05	0.03	0.05	0.09	0.03	0.00	0.04	0.08	0.00	0.01	0.05
	Slushy				7		0.00	0.00	0.06	0.00	0.00	0.00	0.02	0.06	0.01	0.00	0.01	0.00	0.00	0.02	0.01	0.02	0.02	0.00	0.00	0.03	0.00	0.00	0.00	0.09
	Unknown				7		0.00	0.00	0.05	0.00	-354334801920.00	0.00	0.01	0.04	0.01	0.00	0.02	0.00	0.00	0.02	0.01	0.02	0.02	0.00	0.01	0.02	0.00	0.00	0.01	0.00
Time of the Day	4 am - 8 am				199	1790	0.02	0.37	1.57	0.19	-354334801920.00	1.38	0.44	1.61	0.25	0.09	0.41	0.58	0.16	0.52	0.29	0.42	0.60	0.18	0.05	0.43	0.23	0.00	0.04	0.94
	8 am- 10 am				142		0.02	0.28	1.10	0.19	0.00	0.46	0.31	1.13	0.18	0.00	0.30	0.00	0.08	0.38	0.20	0.29	0.48	0.11	0.10	0.33	0.11	0.11	0.03	0.57
	10 am - 4 pm				590		0.07	1.02	4.76	0.13	-1417339207680.00	4.14	1.33	5.17	0.67	0.09	1.01	0.00	0.41	1.73	0.81	1.08	1.65	0.42	0.15	1.73	0.38	0.00	0.17	1.98
	4 pm - 6 pm				307		0.04	0.40	2.52	0.19	-1417339207680.00	0.46	0.71	2.58	0.37	0.09	0.60	0.58	0.16	0.85	0.45	0.62	0.93	0.25	0.08	0.78	0.23	0.05	0.09	1.18
	6 pm - 10 pm				375		0.06	0.40	3.17	0.13	0.00	1.84	0.84	3.57	0.37	0.28	0.65	1.16	0.41	1.14	0.52	0.74	1.22	0.29	0.12	0.93	0.42	0.05	0.11	1.56
	10 pm - 4 am				177		0.02	0.27	1.41	0.13	-1417339207680.00	0.92	0.38	1.49	0.21	0.19	0.43	0.00	0.16	0.48	0.24	0.35	0.46	0.12	0.07	0.42	0.15	0.05	0.08	0.75
Time of the Week	Weekday				1330	1790	0.17	2.04	10.79	0.75	-3189013217280.00	6.44	2.99	11.45	1.54	0.37	2.56	2.32	0.98	3.81	1.87	2.58	3.94	1.02	0.47	3.42	1.18	0.27	0.39	5.09
	Weekend				460		0.06	0.69	3.74	0.19	-1417339207680.00	2.76	1.03	4.11	0.51	0.37	0.85	0.00	0.41	1.31	0.64	0.93	1.40	0.36	0.11	1.20	0.34	0.00	0.13	1.89
Month of Year	Spring	March	April	May	403	1790	0.04	0.67	3.30	0.06	-1063004405760.00	1.84	0.93	3.61	0.44	0.28	0.75	0.58	0.25	1.19	0.55	0.76	1.24	0.30	0.15	1.09	0.27	0.05	0.13	1.18
	Summer	June	July	August	467		0.06	0.75	3.72	0.25	-1771674009600.00	2.30	1.04	3.88	0.57	0.19	0.87	0.58	0.25	1.31	0.65	0.98	1.51	0.36	0.14	1.23	0.61	0.11	0.11	1.75
	Fall	September	October	November	499		0.05	0.81	4.07	0.31	-708669603840.00	3.68	1.11	4.30	0.58	0.19	0.85	0.00	0.25	1.46	0.73	0.96	1.40	0.40	0.13	1.29	0.23	0.11	0.11	2.41
	Winter	December	January	February	421		0.07	0.51	3.44	0.31	-1063004405760.00	1.38	0.94	3.76	0.46	0.09	0.93	1.16	0.66	1.16	0.58	0.81	1.19	0.32	0.15	1.00	0.42	0.00	0.16	1.65
Lighting Conditions	Dark Lighted				437	1790	0.05	0.48	3.70	0.31	-1417339207680.00	1.84	0.98	4.18	0.43	0.37	0.79	0.58	0.16	1.30	0.60	0.86	1.32	0.30	0.17	1.12	0.19	0.05	0.18	1.93
	Dark Un-Lighted				43		0.02	0.12	0.25	0.06	0.00	0.00	0.09	0.15	0.09	0.09	0.15	0.00	0.25	0.06	0.04	0.08	0.10	0.05	0.00	0.03	0.27	0.05	0.02	0.19
	Dawn or Dusk				74		0.02	0.07	0.59	0.06	0.00	0.46	0.17	0.60	0.09	0.00	0.16	0.58	0.16	0.19	0.12	0.17	0.25	0.08	0.03	0.14	0.04	0.00	0.02	0.14
	Daylight				1231		0.14	2.06	9.95	0.50	-2834678415360.00	6.90	2.77	10.57	1.43	0.28	2.29	1.16	0.82	3.55	1.75	2.38	3.64	0.94	0.39	3.32	1.02	0.16	0.30	4.72
	Unknown				5		0.00	0.00	0.04	0.00	-354334801920.00	0.00	0.01	0.06	0.00	0.00	0.01	0.00	0.00	0.02	0.01	0.01	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Road_Contour	Curve On Grade				53	1790	0.01	0.31	0.22	0.06	0.00	0.00	0.11	0.16	0.12	0.09	0.20	0.00	0.25	0.11	0.09	0.08	0.11	0.05	0.01	0.10	0.08	0.00	0.01	0.28
	Curve On Level				90		0.03	0.36	0.45	0.00	-1063004405760.00	2.30	0.18	0.39	0.18	0.37	0.30	0.00	0.33	0.19	0.10	0.16	0.17	0.08	0.07	0.13	0.23	0.11	0.03	0.33
	Hillcrest				9		0.00	0.01	0.07	0.00	0.00	0.00	0.02	0.07	0.01	0.00	0.02	0.00	0.00	0.03	0.01	0.03	0.03	0.01	0.00	0.03	0.00	0.00	0.00	0.00
	Sag				1		0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00
	Straight On Grade				505		0.07	0.76	4.07	0.44	-708669603840.00	3.22	1.12	4.61	0.54	0.00	0.93	0.58	0.41	1.52	0.79	1.04	1.61	0.36	0.12	1.45	0.11	0.05	0.16	1.75
	Straight On Level				1123		0.12	1.27	9.62	0.44	-2480343613440.00	3.68	2.56	10.21	1.20	0.28	1.93	1.74	0.41	3.24	1.51	2.18	3.39	0.87	0.37	2.86	1.10	0.11	0.31	4.62
	Unknown				9		0.00	0.01	0.07	0.00	-354334801920.00	0.00	0.02	0.09	0.01	0.00	0.02	0.00	0.00	0.02	0.01	0.01	0.02	0.00	0.01	0.03	0.00	0.00	0.00	0.00

Contextual Factor	Cell Value	Destination					Public Comments (within 500 ft)						Traffic Volumes			Signalized Left Turn			One or No Vehicle Available		Low Income		Speed Limit				Wejo Data							
														>=10000										>30	>=40		85th %tile Operating Speeds		Quick Acceleration (number of incidents/segment)			Hard Braking		
		City_Facility	Transit_stop	School	Parks	No_destination	Speeding Issue	Intersection Issue	Left turn issue	Crossing Issue	Other	No Comment	<10000	<=20000	>20000	Permitted Only	Permitted & Protected	Protected Only	>=37.5% households have 1 or fewer vehicles available (2019, CBG)	Not	>=14.98% population below federal poverty line (2019, CBG)	Not	<=30	<40	<50	>=50			>20	>5	<=5	>20	>5	<=5
																											<=30	>30	High	<=20	Low	High	<=20	Low
Total length (miles)		633					633						182			104			633		633		143				633		633			633		
Length per attribute (miles)		116	187	174	256	190	36	34	25	24	37	517	48	24	16	1	82	24	147	486	109	524	29	29	79	6	604	319	191	233	444	142	214	448
Total length (feet)		3,342,674					3342674						958,958			547,103			3,342,674		3,342,674		752,729				3,342,674		3,342,674			3,342,674		
Length per attribute (feet)		615,034	985,767	916,522	1,351,194	1,002,154	188,186	182,005	132,259	124,522	196,579	2,727,580	252,360	124,257	82,967	4,155	430,750	127,323	774,707	2,567,967	577,478	2,765,196	155,158	152,603	414,513	30,454	3,188,495	1,686,524	1,008,491	1,229,296	2,345,881	751,398	1,131,212	2,365,331
Crash Rate (3/mile)		0	0	0	0	0	0	0	0	0	0	2	0	1	2	6	10	12	3	3	7	2	1	3	3	0	0	1	2	0	0	2	0	0
	Cell Value	6	6	3	2	2	4	8	4	6	4	1289	6	34	31	5	782	287	492	1298	752	1038	34	92	267	2	165	243	308	57	40	217	92	94
Human Contributing Factors	Driver Inexperience	0.65	0.51	0.28	0.21	0.18	0.45	0.75	0.48	0.81	0.43	0.25	0.67	3.57	3.05	0	77	32	52	128	62	118	2	9	22	0								
	Driver Preoccupied	0.46	0.46	0.26	0.12	0.13	0.34	0.87	0.44	0.59	0.35	0.17	0.54	2.93	2.99	0	62	25	38	105	64	79	0	7	24	0								
	Aggressive Driving	0.24	0.22	0.15	0.05	0.04	0.14	0.09	0.00	0.17	0.08	0.09	0.13	1.32	1.34	0	32	7	20	37	22	35	1	1	5	0								
Crash Type	Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bicycle or Pedal Cycle	0.19	0.20	0.12	0.08	0.03	0.08	0.26	0.04	0.04	0.08	44	0.27	1.15	0.83	0	23	11	13	45	24	34	1	5	9	0	7	8	13	1	1	11	1	3
	Domestic Animal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Other Non-Collision	0.01	0.02	0.01	0.02	0.01	0.03	0.06	0.00	0.00	0.03	7	0.08	0.13	0.06	0	1	2	0	9	5	4	0	1	2	0	2	1	2	1	0	2	0	1
	Pedestrian	0.39	0.30	0.18	0.09	0.05	0.06	0.20	0.08	0.17	0.03	76	0.23	1.40	1.15	1	33	11	29	56	30	55	2	5	15	0	10	12	15	5	2	10	6	6
	Embankment or Ditch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Head On	0.12	0.08	0.06	0.06	0.06	0.06	0.09	0.04	0.13	0.11	28	0.21	0.55	0.25	0	15	1	9	29	14	24	1	3	9	0	5	9	10	2	2	7	5	1
	Overturning	0.13	0.08	0.07	0.06	0.08	0.14	0.17	0.08	0.17	0.19	34	0.40	0.55	0.51	0	18	2	16	31	13	34	2	2	8	0	6	8	10	1	3	5	4	3
	Sideswipe Opposite Direction	0.05	0.07	0.03	0.02	0.01	0.03	0.03	0.04	0.04	0.00	15	0.06	0.21	0.19	0	5	1	6	10	6	10	1	1	1	0	2	1	3	0	0	3	0	0
	Wild Animal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0	0.02	0.00	0.00	0	1	0	0	1	0	1	1	0	0	0	1	0	1	0	0	1	0	0
	Overtaking Turn	0.05	0.06	0.05	0.04	0.02	0.06	0.15	0.00	0.00	0.05	16	0.06	0.42	0.32	0	7	6	1	22	7	16	1	1	3	0	2	4	3	1	2	1	1	4
	Parked Motor Vehicle	0.03	0.04	0.04	0.03	0.06	0.03	0.00	0.04	0.00	0.00	26	0.13	0.04	0.00	1	0	0	6	22	2	26	0	0	4	0	0	4	4	0	0	4	0	0
	Approach Turn	1.30	1.26	0.52	0.23	0.32	0.79	1.80	1.16	1.14	0.67	235	1.07	7.44	7.45	1	218	49	94	253	132	215	8	15	55	2	35	47	62	14	5	46	21	15
	Fixed Object	0.46	0.32	0.20	0.19	0.21	0.31	0.35	0.16	0.55	0.35	113	0.71	2.21	1.78	0	37	13	33	116	63	86	1	11	16	0	10	18	17	7	4	12	6	9
	Other Object	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.04	0.04	0.03	2	0.02	0.08	0.00	0	1	1	1	3	2	2	0	0	0	0	0	0	0	0	0	0	0	0
	Sideswipe Same Direction	0.23	0.23	0.10	0.06	0.03	0.11	0.29	0.20	0.34	0.13	43	0.10	1.06	1.02	0	17	14	24	38	35	27	0	4	6	0	3	8	6	2	3	4	3	4
	Broadside	1.33	1.14	0.57	0.29	0.42	0.76	1.48	0.88	1.23	0.91	265	1.76	6.76	5.98	2	183	54	113	248	155	206	7	10	56	0	31	48	63	7	8	39	21	18
	Rear End	1.98	1.79	0.96	0.54	0.50	1.71	3.02	1.72	2.08	1.29	385	1.13	11.73	11.90	0	223	122	147	415	264	298	9	34	83	0	51	75	99	16	10	72	24	30
Movement (Vehicle 1)	Avoiding Object/Vehicle in Roadway	0.01	0.02	0.01	0.02	0.01	0.03	0.03	0.00	0.13	0.03	5	1	5	1	0	3	1	0	0	0	0	2	1	2	0								
	Backing	0.03	0.01	0.02	0.00	0.01	0.03	0.00	0.00	0.04	0.00	2	1	1	0	0	2	1	1	8	4	5	1	0	0	0								
	Changing Lanes	0.19	0.17	0.07	0.04	0.03	0.08	0.26	0.12	0.17	0.05	33	2	3	12	0	11	12	1	3	2	2	1	1	2	0								
	Drove Wrong Way	0.35	0.26	0.20	0.14	0.10	0.22	0.17	0.12	0.38	0.24	76	26	10	21	0	27	12	16	28	21	23	1	8	15	0								
	Entering/Leaving Parked Position	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	28	71	35	64	0	0	0	0								
	Going Straight	3.33	2.85	1.60	0.89	0.99	2.41	4.93	2.44	3.18	2.39	665	148	157	269	2	404	171	0	0	0	0	17	47	148	0								
	Other	0.03	0.02	0.01	0.01	0.02	0.00	0.00	0.00	0.00	0.00	8	4	1	1	0	2	1	266	685	416	535	0	0	1	0								
	Making Left Turn	1.51	1.56	0.63	0.36	0.41	1.07	1.48	1.28	1.44	0.78	321	82	79	128	2	246	37	4	4	4	4	10	19	70	2								
	Making Right Turn	0.39	0.33	0.15	0.10	0.06	0.14	0.52	0.32	0.25	0.11	68	17	13	25	0	39	23	110	328	173	265	0	7	13	0								
	Making U-Turn	0.03	0.03	0.01	0.04	0.02	0.00	0.00	0.00	0.00	0.03	15	2	2	2	0	1	2	28	67	35	60	1	1	2	0								
	Parked	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1	1	0	0	0	0	0	2	14	4	12	0	0	0	0								
	Passing	0.03	0.01	0.01	0.00	0.01	0.00	0.03	0.08	0.00	0.00	5	2	2	0	0	1	1	1	0	0	1	0	0	1	0								
	Slowing	0.24	0.18	0.09	0.08	0.12	0.17	0.38	0.04	0.21	0.21	51	8	16	23	0	32	18	1	6	3	4	1	4	8	0								
	Stopped in Traffic	0.02	0.02	0.00	0.00	0.01	0.00	0.00	0.04	0.04	0.00	4	0	2	2	0	1	2	20	52	31	41	0	0	1	0								
	Weaving	0.01	0.04	0.02	0.02	0.01	0.00	0.03	0.00	0.08	0.00	9	3	1	3	0	4	0	1	4	1	4	0	1	1	0								
	Unknown	0.11	0.09	0.06	0.02	0.01	0.00	0.03	0.00	0.00	0.00	21	1	7	5	1	7	5	2	10	4	8	0	3	3	0								
Road Condition	Dry	5.63	5.05	2.55	1.50	1.60	3.68	6.88	4.15	5.22	3.30	1159	269	253	443	5	696	260	429	1168	660	937	30	81	230	2								
	Wet	0.39	0.34	0.19	0.12	0.09	0.20	0.75	0.24	0.38	0.35	68	17	26	31	0	54	14	30	77	51	56	1	7	23	0								
	Snowy	0.15	0.13	0.07	0.04	0.03	0.08	0.09	0.04	0.21	0.08	30	8	7	12	0	17	5	18	22	22	18	1	4	7	0								
	Icy	0.04	0.06	0.03	0.04	0.05	0.17	0.12	0.04	0.08	0.08	16	3	7	6	0	8	5	8	18	9	17	0	0	4	0								
	Slushy	0.03	0.02	0.02	0.00	0.01	0.00	0.03	0.00	0.08	0.03	5	1	2	1	0	2	2	4	3	5	2	0	0	1	0								
	Unknown	0.03	0.01	0.01	0.01	0.01	0.00	0.03	0.00	0.00	0.00	6	0	1	0	0	2	1	3	4	5	2	1	0	2	0								
Time of the Day	4 am - 8 am	0.71	0.61	0.35	0.21	0.19	0.39	0.87	0.20	0.47	0.43	148	37	39	52	0	79	32	61	138	83	116	3	12	36	0								
	8 am- 10 am	0.50	0.40	0.25	0.16	0.11	0.31	0.70	0.44	0.59	0.35	95	22	35	39	0	56	24	43	99	61	81	2	9	27	1								
	10 am - 4 pm	2.19	1.86	0.98	0.53	0.57	1.49	2.84	1.52	1.91	1.21	419	96	92	161	1	247	105	170	420	246	344	12	22	85	0								
	4 pm - 6 pm	0.98	0.94	0.45	0.31	0.34	0.67	0.90	0.64	0.81	0.64	238	59	44	85	3	153	24	78	229	138	169	6	19	47	0								
	6 pm - 10 pm	1.30	1.24	0.59	0.36	0.38	0.84	1.74	1.08	1.23	0.81	267	50	65	114	1	180	66	93	282	154	221	8	21	54	1								
	10 pm - 4 am	0.59	0.57	0.28	0.15	0.20	0.45	0.84	0.60	0.98	0.43	122	35	25	43	0	67	36	47	130	70	107	3	9	18	0								
Time of the Week	Weekday	4.74	4.20	2.15	1.31	1.30	3.37	6.01	3.43	4.79	3.01	951	217	231	368	4	570	214	369	961	569	761	24	69	194	2								
	Weekend	1.54	1.41	0.75	0.41	0.50	0.79	1.89	1.04	1.19	0.86	338	82	69	126	1	212	73	123	337	183	277	10	23	73	0								
Month of Year	Spring	1.35	1.29	0.66	0.38	0.44	0.98	1.80	0.96	1.06	0.91	306	63	76	116	1	195	57	126	277	176	227	4	26	40	1								
	Summer	1.57	1.42	0.65	0.49	0.44	1.12	2.03	1.48	1.87	0.94	318	85	60	125	2	197	67	106	361	190	277	9	19	74	0								
	Fall	1.87	1.58	0.89	0.44	0.53	1.12	2.12	1.36	1.61	0.94	363	87	85	141	1	215	81	136	363	211	288	13	24	78	1								
	Winter	1.49	1.32	0.70	0.41	0.39	0.93	1.94	0.68	1.44	1.07	302	64	79	112	1	175	82	124	297	175	246	8	23	75	0								
Lighting Conditions	Dark Lighted	1.60	1.51	0.69	0.38	0.44	0.98	2.26	1.44	1.65	0.89	308	59	65	143	0	207	80	115	322	190	247	8	26	62	0								
	Dark Un-Lighted	0.07	0.07	0.05	0.07	0.07	0.11	0.03	0.04	0.17	0.16	32	13	9	4	0	8	2	5	38	13	30	2	3	1	0								
	Dawn or Dusk	0.24	0.22	0.10	0.09	0.11	0.08	0.26	0.12	0.25	0.19	53	18	15	17	0	33	7	18	56	24	50	1	3	13	1								
	Daylight	4.34	3.81	2.05	1.17	1.17	2.97	5.31	2.87	3.90	2.61	893	209	209	330	5	531	197	352	879	521	710	22	60	190	1								
	Unknown	0.03	0.01	0.01	0.01	0.01	0.00	0.03	0.00	0.00	0.03	3	0	2	0	0	3	1	2	3	4	1	1	0	1	0								
Road_Contour	Curve On Grade	0.20	0.11	0.09	0.06	0.06	0.08	0.03	0.00	0.08	0.11	46	15	5	6	0	10	1	18	35	22	31	0	3	9	0								
	Curve On Level	0.19	0.12	0.13	0.13	0.15	0.25	0.23	0.08	0.25	0.40	64	27	9	17	0	19	6	21	69	30	60	0	6	12	0								
	Hillcrest	0.03	0.03	0.01	0.00	0.01	0.03	0.00	0.04	0.00	0.03	6	0	1	4	0	5	0	2	7	5	4	0	0	1	0								
	Sag	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1	0	0	1	0	1	0	0	1	1	0	0	0	1	0								
	Straight On Grade	2.08	1.69	0.94	0.46	0.49	0.76	1.36	1.40	1.27	0.75	400	71	80	157	3	226	86	197	308	261	244	14	26	78	0								
	Straight On Level	3.73	3.63	1.71	1.05	1.09	3.00	6.18	2.91	4.33	2.58	766	186	204	308	2	517	192	250	873	428	695	18	57	165	2								
	Unknown	0.05	0.03	0.01	0.01	0.00	0.03	0.09	0.04	0.04	0.00	6	0	1	1	0	4	2	4	5	5	4	2	0	1	0								

Out of the contextual factors analyzed the team identified seven factors most associated with fatal and injury crashes. The seven risk factors are shown in **Table 2.** All are associated with above average crash rates (crashes per mile), were found to be sufficiently present in Thornton to be meaningful, and are not all interdependent – meaning together they represent a broad set of different types of factors (i.e. infrastructure factors, operational factors, geographic factors, demographic factors, etc.) and do not always overlap.

Table 2. Contextual Factors Used to Develop the High Risk Network

Contextual Factor	Description	Threshold	Crash Rate
Volume	Count of vehicles along roads. Volumes assigned to road segments between major road intersections. Traffic count data provided by the City of Thornton.	More than 20,000 AADT	31 crashes/mile
Signalized Intersection	Intersection with traffic signal installed at the time of the crash. Signal location data provided by the City of Thornton.	Within 250 feet of a signal	16 crashes/mile
Operating Speed	85th percentile operating speeds. Data derived from operating speed data collected in 2022 by Wejo.[2]	More than 30 MPH	.47 crashes/mile[2]
Household Income	Block groups within the lowest quartile of household income within Thornton city boundaries (15% of the population at or below the federal poverty line.) 2019 Census block group data, American Community Survey 5-year estimates.	15% of the population is at or below the federal poverty line	7 crashes/mile
Transit Stops and Stations	RTD bus and light rail stops. Data provided by RTD.	Within 800 feet of a transit stop or station	6 crashes/mile
Land Use	Land use of parcels in Thornton. Data provided by the City of Thornton.	Along commercial or institutional land use	5 crashes/mile
Community Input	Locations of traffic safety concerns provided by the community through the online survey interactive map. Data collected in spring and summer of 2024.	Within 500 feet of a public comment	5 crashes/mile

[2] Wejo is a Big Data provider, that provides operating speed data sourced from in-vehicle navigation systems. Wejo's data set includes a subset of roads as well as many driveways, parking lots, and alleys. The average crash rate for segments with operating speed data was .22 crashes per mile, meaning the crash rate for segments with over 30 MPH operating speeds is over twice as high as the average.

The average crashes per mile across all city streets over the five-year study period was three crashes per mile.

It should be noted that when calculating crashes per mile where each risk factor occurred some data was available city-wide and crash rates of the selected contextual factor can be compared to the City's average of three injury crashes per mile. Other data was not available city-wide. In these cases, segments with the presence of those contextual factors received a calculated average crash rate which were then compared to the average for each stratified threshold. For example, only 104 miles of the City's 633 miles of road had traffic volume data available. The injury crash rate for those roads in total is six injury crashes per mile. The injury crash rate for roads with less than 10,000 ADT was also six injury crashes per mile but for segments with volumes between 10,000 ADT and 20,000 ADT was 13 crashes per mile, and segments with over 20,000 ADT (the selected threshold for the HRN) had a crash rate of 31 injury crashes per mile, well over the average of six crashes per mile demonstrated by sum total of the segments with available data.

Mapping the High Risk Network

Thornton's High Risk Network comprises roadway segments where at least four of the seven contextual risk factors described here are present.

Combining into the High Injury Network + High Risk Network

The HIN and HRN were combined on a map to form the HIN + HRN.

Level of Service of Safety Analysis

What is Level of Service of Safety (LOSS)?

Level of Service of Safety (LOSS) is a metric used to assess whether a location has more or less crashes per vehicle volume than average relative to other similar locations in Colorado. It is useful for identifying locations with a higher potential for safety improvements and is commonly used by the Colorado Department of Transportation (CDOT) to prioritize safety improvement projects.

The LOSS score ranges from 1 to 4 based on the crash rate percentile of a given location relative to all other locations in Colorado:

- LOSS I (<20th percentile) Lower potential for crash reduction.
- LOSS 2 (20th to 50th percentile) Lower to moderate potential for crash reduction.
- LOSS 3 (50th to 80th percentile) Moderate to high potential for crash reduction.
- LOSS 4 (>80th percentile) High potential for crash reduction.

LOSS Analysis Methodology

The contextual characteristics necessary to determine a LOSS score include average daily traffic volumes, whether the intersection is signalized, and the number of street segments connected to the intersection, among other factors. LOSS is based on the concept of Safety Performance Functions and was developed by the Colorado Department of Transportation.[3]

Based on crashes within Thornton between 2018 and 2022, LOSS scores were determined for

- All arterial-arterial intersections with 15 or more crashes
- Any intersection with 1 or more fatalities
- Any intersection with 1 or more bicycle or pedestrian crash

Intersections with more crashes or more severe crashes than similar locations across the state were considered for inclusion in the initial list of safety project locations.

Priority Intersection Identification

Priority intersection projects included in the Vision Zero Action Plan were identified using the following criteria for the study period (2018-2022), primarily based on crash history:

- Intersections with level of service of safety (LOSS) of 4
- Intersections on the HIN+HRN with a LOSS of 3

[3] Federal Highway Administration, 2011. "Level of Service of Safety and Diagnostic Analysis." Available at https://highways.dot.gov/safety/learn-safety/noteworthy-practices/level-service-safety-and-diagnostic-analysis.

- Intersections on the HIN+HRN with a bicycle, pedestrian, or fatal crash
- Intersections identified by multiple community members as a location of concern

Most of the priority projects identified using this methodology are on the HIN + HRN as safety improvements to these roadways will have the greatest impact on safety.

Priority Corridor Identification

Access Management

Priority street segments were identified for access management and pedestrian & bicycle crossing safety interventions. Fehr & Peers paired multiple analytic methods to understand trends for the crash study period (2018-2022) with professional judgement to finalize the priority list. All prioritized street segments are on the HIN + HRN with:

- A high concentration of driveway related crashes
- A high concentration of left turn, broadside, and/or pedestrian and bicycle crashes that are more than 250 feet from a signalized intersection.

Crashes related to driveways and unsignalized intersections were filtered in two ways:

- Crashes where the road location was labeled "at driveway access"
- Crashes where the type was approach turn, broadside, pedestrian, or bike, and where the location was at least 250 feet from a signal.

The resulting crash layers were analyzed using two approaches, as follows:

Approach 1: The HIN + HRN was divided into quarter-mile-long segments, and crashes within 50 feet were spatially joined to it. A crash rate (crashes per mile) was calculated for the two layers, and the layers symbolized with four classes by quantile. Those segments in the highest quantile were considered for inclusion in the Access Management Corridor list.

Approach 2: The analyst applied the sliding window script used for the High Injury Network development to identify priority corridors for access management. The window length was again set to 1,320 feet, the shift to 528 feet, and the search radius to 50 feet.

Crashes were assigned a weight based on severity, where fatal and severe injury crashes received a weight of 3, other injury crashes received a weight of 2, and property damage crashes received a weight of one.

After running the sliding window tool using each definition of crashes, a second script isolated segments that scored in the 98th percentile and smoothed them so that segments up to 2,640 feet apart were joined together. All corridors identified using the "at driveway access" field were on the HIN + HRN. The corridors generated using the second approach to filtering crashes yielded two small segments that were not on the HIN + HRN. These were excluded from the final layer.

Fehr & Peers studied the corridors identified through these two methods using aerial imagery, crash data, and a field visit. The analysis resulted in the following high priority street segments and intersections for access management safety interventions and improved pedestrian/bicycle crossings:

- Washington Street - 84th Avenue to Thornton Parkway
- Colorado Boulevard – 100th Avenue to 121st Avenue
- 84th Avenue - Huron Street to I-25
- 104th Avenue – Washington Street to Irma Drive
- 88th Avenue – Grant Street to Corona Street
- 88th Avenue - York Street to Devonshire Street
- Huron Street – 88th Avenue to 97th Avenue

Speed management

The risk for severe crashes is highest in locations with high traffic volumes, high vehicle operating speeds, and high concentrations of pedestrians and bicyclists. Priority street segments for speed management safety interventions include corridors on the HIN + HRN where these factors are high:

- Traffic volumes
- 85th percentile operating speeds
- Pedestrian and bicycle-involved crashes (2018-2022)

Traffic volume data came from the City of Thornton and DRCOG. Counts were joined to quarter-mile long segments of the HIN +HRN. Because traffic volumes were not available for all segments, we interpolated volumes using the Natural Neighbors interpolation method in ArcGIS Pro using volumes on the HIN+HRN as inputs. We converted the resulting raster into points and joined them to the street segments. We compared observed to interpolated volumes where possible; the mean ratio of observed to interpolated volumes was 0.98 and the median ratio was 1.01, giving us confidence that the interpolated volumes were reasonable.

Speed data were purchased from Wejo, which provides data from connected vehicles. This data includes millions of data points with coverage across the city.

Speeds and volumes were spatially joined to roadway segments with 50-foot, flat-ended buffers. The team used median values for cases where multiple points were joined to each road segment to minimize the effect of outliers in the data. Speeds and volumes were multiplied, and the resulting value symbolized in four classes by quantiles. To this layer, we added bicycle and pedestrian crash rates per mile. Where the crash rate was greater than zero, we multiplied the crash rate by the speed times volume calculation to identify the riskiest areas for pedestrians and bicyclists.

The resulting corridors were smoothed using professional judgement and knowledge of the area, resulting in the following priority street segments:

- Washington Street – 84th Ave to 98th Avenue
- Washington Street – 120th Avenue to 130th Avenue
- Colorado Boulevard – 100th Avenue to 121st Avenue
- 84th Avenue – Huron Street to Washington Street
- 88th Avenue – I-25 to Colorado Boulevard
- 120th Avenue – I-25 to Colorado Boulevard

To this list, we added Washington Street from 144th Ave to 146th Ave, which was identified by the Police Department in a previous analysis.

Run-Off-the-Road

To identify stretches where run-off-the-road crashes are unusually common, we identified fixed object crashes and excluded those where drug or alcohol impairment, aggressive driving, falling asleep at the wheel, or medical emergencies were contributing factors, as those factors are independent of the geography and often associated with run-off-the-road crashes in urban/suburban contexts. We joined these crashes to the quarter-mile-long segments of the

HIN+HRN, using a 50-foot search radius, and calculated a per mile crash rate. Segments were symbolized with four classes by quantile.

The results from this analysis did not reveal any notable hotspots. Given these findings, no specific segments were prioritized for run-off-the-road countermeasures. However, the other improvement projects and action items, in particular speed management, will also have a positive impact in mitigating these types of crashes. Thus, it is recommended that Thornton move forward with the other safety improvement projects and action items to address this crash type.